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Assessing value co-creation in blockchain enabled learning certificates: a knowledge management perspective.

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Abstract: Blockchain enabled learning certificates promise immutable, transparent proof of skills and achievements, yet their potential for sustained value co - creation remains underexplored. Grounded in Nonaka and Takeuchi's SECI model, Service-Dominant Logic, and the Co-Creation Triad, this position paper advances an integrative analytical model to evaluate how blockchain credentials instantiate knowledge-conversion processes, operant resource integration, and stakeholder engagement structures. A dual-stream methodology first maps construct from 50 prior studies to these lenses - revealing a research landscape heavily focused on technical architectures but largely neglectful of on-chain Socialization, Internalization, and ongoing co-creation incentives. We then apply our model to four illustrative platforms (LearnCoin, Blockcerts, Badgr, and the Learning Economy Foundation), systematically coding each system's support for explicit knowledge externalization/combination, smart-contract-driven workflows, and dialogic customization. Our cross-case analysis confirms universal strengths in artifact codification and protocol automation but identifies persistent gaps in reflective learning cycles and sustained co-creation mechanisms. We conclude by calling for next-generation credential designs that embed on-chain communities of practice, adaptive operant resources, and multi-phase token economies, thereby charting a research and design roadmap for transforming blockchain certificates into living ecosystems of shared learning value.

1 INTRODUCTION

Blockchain technology has emerged as a promising solution for enhancing trust and transparency in credentialing systems (Alkhudary & Gardiner, 2024; Pham et al., 2024; Zhou et al., 2024). By decentralizing record-keeping, blockchains can reshape how institutions, learners, and employers verify and exchange credentials (Zhou et al., 2024; Jin et al., 2023; Pokhrel & Shrestha, 2021). However, immutability and shared governance do not automatically improve how knowledge is created, shared, or leveraged.

From a knowledge management perspective, it is critical to examine how stakeholders collaborate in these ecosystems. Value co-creation, the joint production of mutual benefits depends on more than reliable technology (Pham et al., 2024; Xie & Zhang, 2023; Tlili et al., 2021). It requires supportive structures, incentives, and open channels for exchange. Without alignment, blockchain-based certificates risk becoming technical artifacts rather than catalysts for learning communities (Pham et al., 2024; Xie & Zhang, 2023; Markopoulos et al., 2022).

We argue that effective blockchain credentialing must integrate robust KM strategies. Embedding principles such as stakeholder engagement, transparent communication, and collective sensemaking enables genuine value co-creation.

Moreover, we contend that Future research and practice should therefore focus on the interplay between technological design and KM processes to ensure blockchain-enabled certificates succeed. Highlighting this intersection reveals both opportunities and challenges in embedding blockchain into educational ecosystems from a knowledge management standpoint.

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1.2 Background of the study

Blockchain's decentralization, immutability, and transparency tackle key credentialing issues; verification delays, data breaches, and fraud (Tripathi, Ahad & Casalino, 2023; Vipie, Afumatu & Caramihai, 2023) by letting learners securely control tamper-proof records and enabling instant, intermediary-free validation (Pu & Lam, 2023). When paired with robust KM infrastructures; such as the Blockchain of Learning Logs for seamless cross-institutional record sharing (Ocheja et al., 2019), it supports secure knowledge capture, storage, and reuse, allowing institutions, learners, and employers to co-create value via shared understanding, trustworthy credentials, and efficient information flows (Zamiri & Esmaeili, 2024).

2 THEORETICAL FOUNDATION

We draw on two KM theories and two service-science frameworks to build our analytical model. Nonaka and Takeuchi's SECI model identifies four knowledge conversion modes; Socialization, Externalization, Combination, and Internalization and highlights how blockchain's immutable ledger enhances Externalization and Combination by encoding credentials as explicit records, while peer-verified exchanges can support Socialization and Internalization (Nonaka & Takeuchi, 1995; Pham et al., 2024). The Knowledge-Based View (KBV) frames certificates as portable artifacts: smart contracts standardize data, lower verification costs, and enable seamless knowledge flows across institutions, learners, and employers (Grant, 1996; Tlili et al., 2021).

Service-Dominant (S-D) Logic views value as emerging from service-for-service exchanges rather than being embedded in products (Vargo & Lusch, 2004). In credentialing ecosystems, blockchain platforms act as operant resources, with smart contracts and decentralized networks enabling learners, issuers, and verifiers to integrate competencies and co-produce value (Xie & Zhang, 2023).

The stakeholder co-creation triad emphasizes engagement, transparency, and mutual customization (Prahalad & Ramaswamy, 2004). Blockchain's real-time visibility supports this dialogue: learners set goals, institutions validate achievements, and employers endorse competencies, tailoring and legitimizing credentials collaboratively (Markopoulos et al., 2022).

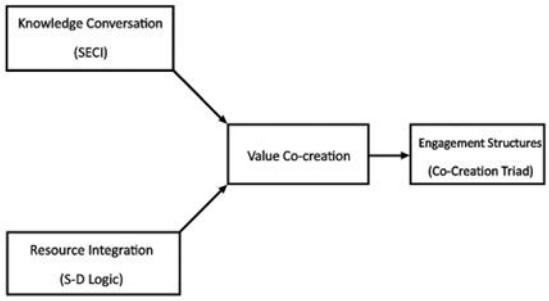

Figure1: Integrative Socio-Technical Model of Value Co-Creation in Blockchain-Enabled Learning Certificates

Synthesizing SECI, KBV, S-D Logic, and the co-creation triad, our integrated model (Figure 1) treats blockchain-enabled certificates as socio-technical artifacts whose affordances must align with KM processes and co-creation mechanisms to generate sustainable, mutual value. The model spans three dimensions: (1) Knowledge Conversion (SECI), (2) Resource Integration (S-D Logic), and (3) Stakeholder Engagement (Co-Creation Triad). It offers a foundation for evaluating certificate platforms; subsequent sections apply these lenses to real-world cases.

2.1 Main thesis and Position

We posit that *blockchain-enabled learning certificates, when embedded within robust knowledge management (KM) practices, can facilitate value co-creation among educational institutions, learners, and employers*.

While blockchain's decentralization and transparency foster trust in credentialing systems (Sharples & Domingue, 2016; Grech & Camilleri, 2017), genuine collaboration and knowledge exchange hinge on frameworks that align stakeholders and cultivate open sharing cultures (Nonaka & Takeuchi, 1995; Wenger, 1998). Consequently, blockchain's technical affordances must be reinforced by KM centric processes, such as communities of practice, incentive mechanisms, and shared goal setting, to transform credentials from static proofs into catalysts for continuous, co - creative learning ecosystems (Vargo & Lusch, 2004; Prahalad & Ramaswamy, 2004).

3 METHODOLOGY

This section outlines our dual stream, theory driven approach, combining a structured synthesis of KM and value co creation literature with an illustrative multiple case analysis of real-world blockchain

credential platforms. We then detail how we selected cases, gathered data, and applied our integrative analytical model in three systematic steps.

3.1 Research Approach

We adopt a qualitative, multiple-case, theory-driven approach to illustrate how blockchain certificate platforms instantiate our KM and value co-creation model. This aligns with the goal of a position paper: to argue a conceptual stance through real-world examples.

3.2 Literature search and Synthesis

A literature review was conducted to synthesize existing knowledge in three areas: blockchain in education, value co-creation theory, and knowledge management frameworks. Using the Web of Science (WoS) database, we applied a structured Boolean search: ("blockchain" OR "distributed ledger") AND ("learning certificate*" OR "digital credential*" OR "digital certificate*" OR "educational credential*") AND ("value co-creation" OR "value cocreation" OR "co-creation of value" OR "service-dominant logic" OR "knowledge management" OR "knowledge creation" OR "knowledge sharing" OR "communities of practice"). The search was limited to peer-reviewed journal articles, conference proceedings, and reviews from the last five years to ensure contemporary relevance. Articles were screened for direct relevance, and an analytical framework (Figure 2) was developed by integrating Service-Dominant Logic (Vargo & Lusch), Nonaka's SECI model, and Wenger's communities of practice. This framework provided a structured lens to examine how blockchain technologies can facilitate value co-creation in education.

3.3 Case selections

We purposively selected four blockchain credential initiatives; LearnCoin, Blockcerts, Badgr on Ethereum, and Learning Economy based on: 1) Blockchain type: public vs. consortium, 2) Maturity: pilot vs. production, 3) Stakeholder diversity: learners, issuers, verifiers.

3.4 Limitations

As a position paper, our cases are illustrative rather than representative; and while we grounded our argument in peer-reviewed theory, we did not conduct full-scale empirical testing.

3.5 Analytical procedure

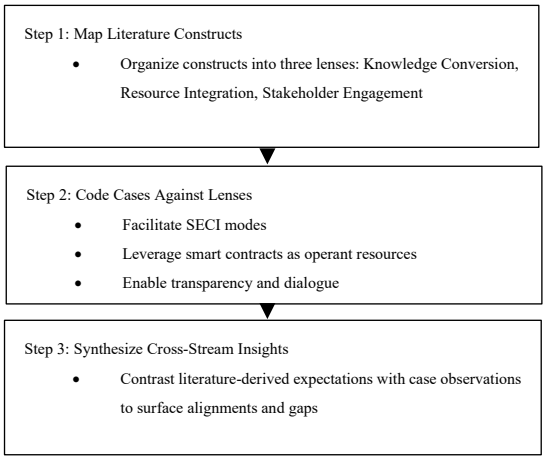

Figure 2: Analytical procedure for dual stream analysis.

4 FINDINGS

In this section, we present the results of our dual-stream analytical process. First, we map the "Findings" from fifty prior studies onto our three theoretical lenses to reveal how extant literature aligns with (or diverges from) our integrative model (See figure 1). Next, we apply these lenses to four illustrative blockchain credential platforms (LearnCoin, Blockcerts, Badgr, and the Learning Economy Foundation), systematically coding each system's support for explicit knowledge flows, operant resource integration, and stakeholder engagement mechanisms. Finally, we synthesize cross-case patterns to identify common strengths, shared gaps, and unique practices, setting the stage for the broader theoretical and practical implications discussed in Section 5.

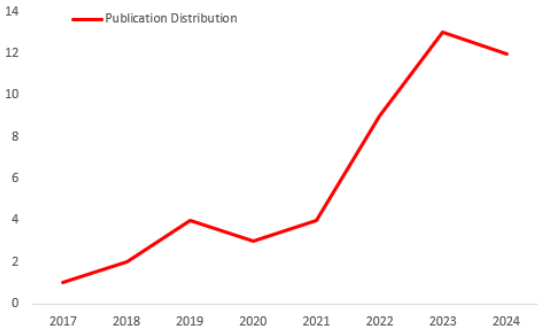

Figure 3: Article Distribution 2017- 2024.

Research on blockchain-enabled learning credentials surged from 2020, peaking in 2024, driven by rapid

blockchain adoption, evolving digital credential practices, and COVID-19–induced digital transformation. While this growth signals strong interest, it also demands careful vetting to distinguish trend-driven studies from robust scholarship. The work appears across diverse outlets, from Journal of Knowledge Management and Information Sciences to IEEE Internet of Things Journal and Sustainability, reflecting an interdisciplinary convergence of KM, educational technology, blockchain, and digital trust. Leading conferences (ECKM, AIS, ICCE, iMeta) underscore themes like speculative system architectures, decentralized learning models, and trust-centered innovation. References to the metaverse, XR, and sustainability further point to a vision of blockchain credentials as integral components of inclusive, transparent, and future-ready learning ecosystems.

4.1 Mapping Literature Constructs to Analytical Lenses

To understand how existing blockchain, KM research aligns with our theoretical model (See figure 1), we mapped the "Findings" from all 50 studies in our dataset to the three analytical lenses introduced in Section 3; Figure 2. The table below summarizes the distribution (Table 1). For the first three categories we provide all available citations; the full list of uncategorized papers, citations are available in Appendix A.

1. Service-Dominant Logic (Resource Integration)

Ten studies foreground blockchain elements smart contracts, protocols, or token economies as operant resources that structure knowledge workflows. For example, Alkhudary and Gardiner (2024) demonstrate that embedding smart contracts in project management information systems streamlines credential verification, while Wang and Li (2024) describe a blockchain-based orchestration layer that binds federated-learning assets into coherent service offerings. These works confirm that protocols and smart contracts are central to how stakeholders integrate and exchange knowledge in credentialing ecosystems.

Table 1: Count of studies mapped to each analytical lens.

Analytical Lenses	Number of studies	Key References
Service-Dominant logic (Resource Integration)	10	Alkhudary & Gardiner (2024); Wang & Li (2024); Zhou et al. (2024); Pham et al. (2024); Hu et al. (2028); Alagha et al. (2024); Bestas et al. (2023); nan (2019); Pfeiffer et al. (2020), Wu et al., (2024).
Co-creation Triad (Stakeholder Engagement)	8	Alkhudary & Gardiner (2024); Xie & Zhang (2023); Zhou et al. (2024); Chai et al. (2020); Fu et al. (2023); Hu et al. (2018); Pham et al. (2024); nan (2023)
SECI (Knowledge creation)	3	Chai et al. (2020); Zhou et al. (2024); Markopoulos et al. (2022)
Uncategorized	33	-

2. Co-Creation Triad (Stakeholder Engagement)

Eight studies examine incentive, transparency, and dialogic mechanisms that drive stakeholder participation. Xie and Zhang (2023) show how token-based incentives on chain dramatically increase community contributions, and Zhou et al. (2024) highlight how on-chain "distilled" knowledge artifacts circulate among peers, fostering collaborative engagement. Such research illustrates blockchain's capacity to enable mutual customization and open dialogue among learners, issuers, and verifiers.

3. SECI (Knowledge Conversion)

Only two studies explicitly address SECI's knowledge conversion processes. Chai et al. (2020) externalize tacit vehicular insights into immutable blockchain records enabling both Externalization and Combination while Zhou et al. (2024) also point to on-chain artifact sharing as a form of Socialization. The relative scarcity of SECI focused work suggests an important gap: few researchers have framed blockchain credentials in terms of broader KM cycles.

4. Gaps and Opportunities

A majority of studies (33) did not map clearly onto our three lenses, typically emphasizing security, performance, or technical architecture instead. This landscape reveals two key opportunities for our case analyses: 1) Deepening KM Cycles - Investigate how real-world platforms support the underexplored SECI modes (especially Internalization), 2) Enriching Co-Creation - Examine whether case platforms extend beyond simple incentive schemes to foster sustained

dialog and mutual customization. These insights establish a clear baseline against which to evaluate our four illustrative blockchain certificate initiatives in Section 4.2.

4.2 Case-by-Case Lens Application

In this section, we demonstrate how our integrative analytical model (SECI, Service - Dominant Logic, Co - Creation Triad) manifests in practice by applying it to four prominent blockchain credential platforms. For each case, we systematically map key features and mechanisms onto our three theoretical lenses, illustrate with concrete examples, and assess the degree to which each platform supports knowledge conversion, resource integration, and stakeholder engagement. This detailed comparison will surface both best practices and persistent gaps, setting the stage for our cross-case synthesis in Section 5.

To ensure consistency across all four case studies, we apply a simple three-point support rubric; High, Medium, Low, when mapping platform features onto our three lenses. A High rating denotes that a capability is natively built into the on-chain protocol or core smart-contract logic, fully addresses most sub-dimensions of the lens (e.g., both Externalization and Combination for SECI), and is central to everyday issuance or verification workflows. A Medium rating indicates the feature exists - often via optional smart-contract hooks or dashboard support - but only covers one sub-dimension well (e.g., one-off token incentives) or plays a secondary role. A Low rating means the feature is absent or only supported off-chain, forcing stakeholders to rely on external tools or manual processes (e.g., no on-chain dialog for Socialization). We will use this rubric to assess LearnCoin and then apply the same criteria to the three other platforms in turn.

4.2.1 Case study: LearnCoin

LearnCoin is a unified "currency for learning" platform that issues, verifies, and transfers educational credentials on a public blockchain. Below, we map LearnCoin's core features onto our three lenses, illustrate with concrete examples, and assess support levels. All feature details are drawn from the LearnCoin website (LearnCoin, n.d.).

Table 2: Mapping LearnCoin Features to SECI, Service-Dominant Logic, and Co-Creation Triad Lenses.

Lens	Observations	Support level
SECI (Knowledge Conversion)	Externalization: Every issued credential is hashed and recorded on-chain, turning tacit learner achievements into explicit, immutable artifacts (LearnCoin, n.d.). Combination: Dashboard and explorer aggregate on-chain data into comprehensive learner portfolios (LearnCoin, n.d.). Socialization/Internalization: No on-chain forum or narrative annotations; learners must export credentials off-chain for reflection (LearnCoin, n.d.).	Externalization: High Combination: High Socialization/Internalization: Low
S-D Logic (Resource Integration)	Operant Resources: Smart contracts automate issuance, revocation, and credit-transfer workflows between institutions (LearnCoin, n.d.). Protocol as Backbone: The LearnCoin token mediates value exchange - micro-credentials, upskilling credits - across diverse providers, acting as the platform's service "currency" (LearnCoin, n.d.).	High
Co-Creation Triad (Engagement)	Transparency**:** All credential transactions are publicly verifiable, enabling any stakeholder to audit issuance histories (LearnCoin, n.d.). Dialog & Customization: LearnCoin offers off-chain FAQs and blog posts but lacks on-chain messaging channels for learner–issuer dialogue	Transparency: High Dialog/Customization: Low Incentives: Medium

	or credential co-design (LearnCoin, n.d.). Incentives: Token rewards for early adopters and validators spur initial participation but do not support ongoing co-creation (LearnCoin, n.d.).	

4.2.2 Case study: BlockCerts

Blockcerts is an open-source standard and toolkit - comprising developer libraries, a mobile wallet, and a universal verifier - that enables the creation, issuance, viewing, and on-chain verification of blockchain credentials (Blockcerts, n.d.). Table 3 maps its core features onto our SECI, Service-Dominant Logic, and Co-Creation Triad lenses, using the same High/Medium/Low rubric introduced in Section 4.2.

Table 3: Mapping BlockCerts Features to SECI, Service-Dominant Logic, and Co-Creation Triad Lenses.

Lens	Observations	Support Level
SECI (Knowledge Conversion)	Externalization: Issuers hash credential assertions (batch Merkle roots) into Bitcoin transactions (OP_RETURN), converting tacit proof of achievement into immutable, explicit records (Blockcerts, n.d.). Combination: The universal verifier and mobile wallet assemble on-chain proofs into human-readable certificates (Blockcerts, n.d.). Socialization/Internalization: A public community forum invites discussion, but there is no on-chain peer-to-peer annotation or reflective storytelling.	Externalization: High Combination: High Socialization/Internalization: Medium
S-D Logic (Resource Integration)	Operant Resources: Smart-contract-style workflows (batch issuance, revocation lists) and Merkle-proof verification functions are provided as reusable libraries (Blockcerts, n.d.). Protocol as Backbone**:** The OP_RETURN protocol and open JSON schemas standardize credential format, enabling any compliant application to integrate issuance and verification services.	High
Co-Creation Triad (Engagement)	Transparency: All credential transactions and revocation events are publicly verifiable on Bitcoin, offering full auditability (Blockcerts, n.d.). Dialog & Customization: The community forum supports off-chain technical dialogue and co-development of the standard; however, credential attribute customization occurs in off-chain issuer tooling rather than via on-chain mechanisms (Blockcerts, n.d.). Incentives: No native token or reward mechanism; participation is driven by open-source collaboration.	Transparency**:** High Dialog/Customization: Medium Incentives: Low

Illustrative Examples:

Externalization: An academic institution issues a cohort diploma by hashing its Merkle root into Bitcoin's OP_RETURN, making proof of issuance tamper-proof (Blockcerts, n.d.).

Operant Resource: A third-party verifier imports the JSON credential into the universal verifier web app, which runs Merkle-proof checks against the blockchain to confirm authenticity (Blockcerts, n.d.).

Engagement: Developers propose schema extensions in the public forum, enabling incremental co-design

of credential types - though these discussions and customizations occur off-chain.

Blockcerts thus provides robust on-chain knowledge conversion and resource-integration capabilities, and a transparent - but primarily off-chain - environment for co-creation. Its lack of native incentive tokens and absence of on-chain socialization tools highlight areas for future enhancement.

4.2.3 Case study: Badgr

Badgr implements the Open Badges standard on Ethereum, enabling issuers - from K–12 schools to professional training providers - to mint, share, and verify micro-credentials (Badgr, n.d.). Table 4. maps Badgr's core capabilities onto our SECI, Service-Dominant Logic, and Co-Creation Triad lenses, using the High/Medium/Low rubric.

Table 4: Mapping Badgr Features to SECI, Service-Dominant Logic, and Co-Creation Triad Lenses.

Lens	Observations	Support Level
SECI (Knowledge Conversion)	Externalization: Issuers define badge criteria and metadata in JSON, then anchor badge assertions on-chain converting tacit learner achievements into explicit, verifiable records (Badgr, n.d.). Combination**:** The Badgr Backpack and dashboard aggregate badges into learner portfolios, enabling new badge "collections" (Badgr, n.d.). Socialization/Internalization**:** Learners can comment on and endorse peers' badges within group cohorts, fostering Socialization and reflection.	Externalization: High Combination: High Socialization/Internalization: Medium
S-D Logic (Resource Integration)	Operant Resources: Ethereum smart contracts mint, transfer, and revoke badges; Badgr's RESTful APIs expose these functions for integration into LMSs and corporate HR systems (Badgr, n.d.). - Protocol as Backbone: The Open Badges JSON schema and Ethereum token flows standardize credential exchange, allowing any compliant system to integrate micro-credential services.	High
Co-Creation Triad (Engagement)	Transparency: Badge metadata and issuance events are viewable on-chain and via the Badgr.org public gallery (Badgr, n.d.). - Dialog & Customization: Educators co-design badge criteria with learners using off-chain authoring tools; built-in cohort forums let recipients discuss criteria and provide feedback (Badgr, n.d.). - Incentives: Gamified badge "pathways" and social leaderboards incentivize sustained participation beyond one-off issuance.	Transparency: High Dialog/Customization: Medium Incentives: High

Illustrative Examples

Externalization: A coding bootcamp issues a "JavaScript Essentials" badge by embedding a hash of the badge assertion into an Ethereum transaction, ensuring tamper-proof proof of skill (Badgr, n.d.).

Combination: A learner's Badgr Backpack automatically groups all "Web Dev" badges into a single "Full Stack" collection for easy sharing.

Engagement*:* Within a cohort's pathway, peers' comment on one another's project badges, offering feedback that learners internalize to improve subsequent badge applications.

Badgr thus excels not only at on-chain knowledge conversion and resource integration but also fosters richer engagement through gamified incentives and off-chain co-creation tools - addressing some of the gaps observed in LearnCoin and Blockcerts.

4.2.4 Case study: Learning Economy Foundation

The Learning Economy Foundation (LEF) stewards a Web3 "Internet of Education," providing open, API-driven platforms; LearnCard, LearnCloud, ScoutPass, Metaversity - for issuing, storing, and sharing verifiable credentials and skills portfolios (Learning Economy Foundation, n.d.). Using our High/Medium/Low rubric, Table 5. maps LEF's core capabilities onto the SECI, Service-Dominant Logic, and Co-Creation Triad lenses.

Table 5: Mapping Learning Economy Foundation Features to SECI, Service-Dominant Logic, and Co-Creation Triad Lenses.

Lens	Observations	Support Level
SECI (Knowledge Conversion)	Externalization: LearnCard mints "Skills Passports" (VCs) on-chain via Merkle proofs, converting tacit learner achievements into explicit, immutable tokens (Learning Economy Foundation, n.d.). Combination: LearnCloud's dashboard and portfolio APIs aggregate credentials and pathway data into cohesive learner profiles (Learning Economy Foundation, n.d.). Socialization/Internalization: Community "ScoutPass" cohorts and forum discussions exist off-chain; no native on-chain annotation or narrative tools for reflection.	Externalization: High Combination: High Socialization/Internalization: Medium
S-D Logic (Resource Integration)	Operant Resources: LEF provides SDKs and RESTful APIs (LearnCard, LearnCloud) that encapsulate issuance, revocation, and credential–wallet interactions as reusable operant resources (Learning Economy Foundation, n.d.). Protocol as Backbone: The Internet of Education protocols (Open Skills, LER, W3C universal wallet) standardize credential formats and enable interoperability across any compliant system.	High
Co-Creation Triad (Engagement)	Transparency: All credential issuance and revocation events are publicly verifiable via blockchain explorers and LEF dashboards (Learning Economy Foundation, n.d.). Dialog & Customization: Off-chain community forums, "Position Paper" working groups, and roadmap feedback channels enable co-design of protocol extensions; credential metadata schemas are customizable in issuer tooling. Incentives: "Earn-to-Learn" pilots (e.g., ScoutPass token rewards) and "Advance Colorado" partnerships offer localized token incentives, though these remain experimental.	Transparency: High Dialog/Customization: Medium Incentives: Medium

Illustrative Examples:

Externalization: A learner's completion of a SuperSkills LEGO quest is hashed into a ScoutPass NFT, ensuring tamper-proof proof of play-based skill acquisition (Learning Economy Foundation, n.d.).

Operant Resource: An employer's HR system calls LearnCloud's credential-verification API to pull and verify a candidate's LearnCard portfolio without manual intervention (Learning Economy Foundation, n.d.).

Engagement: In LEF's "Advance Colorado" pilot, learners earn tokens for completing statewide workforce credentials - an experimental incentive mechanism designed to co-create curriculum via stakeholder feedback (Learning Economy Foundation, n.d.).

LEF's ecosystem demonstrates robust on-chain knowledge conversion and protocol-driven resource integration, with evolving but still maturing approaches to on-chain socialization and incentive design - highlighting both its leadership in credential interoperability and areas for deeper co-creation practice.

4.3 Cross – case patterns

Bringing together our four case studies LearnCoin, Blockcerts, Badgr, and the Learning Economy Foundation reveals clear commonalities, shared gaps, and distinctive approaches across the three lenses:

Table 6: Cross-case pattern summary

Pattern Type	SECI (Knowledge Conversion)	S-D Logic (Resource Integration)	Co-Creation Triad (Stakeholder Engagement)
Common Strengths	•Externalization & Combination (4/4)	•Smart contracts & protocols as operant resources (4/4)	•Full transparency of credential transactions (4/4)
Shared Weaknesses	•On-chain Socialization /Internalization absent (0/4)	• N/A (all cover resource integration fully)	•Ongoing incentive mechanisms weak or one-off (1/4)
Variant Practices	•Badgr offers peer endorsement (1) •LEF forums & working groups (1)	• LEF's Open Skills protocols enable cross-platform interoperability	•Badgr gamified pathways (High) • LEF pilot tokens (Medium) •LearnCoin one-off rewards (Medium) •Blockcerts open-source collaboration (Low)

Externalization & Combination: Every platform writes hashes on-chain and provides dashboards/APIs to recombine records into learner portfolios, confirming the centrality of explicit KM artifacts in blockchain credentials.
Operant Resources: All four systems treat smart contracts, token protocols, or standards (OP_RETURN, Open Badges JSON, Internet of Education) as reusable operant resources that automate issuance, revocation, and verification.

Transparency: Public blockchains guarantee auditability across all cases, underscoring blockchain's unique value for verifiable credentials.
Lack of On-chain Socialization/Internalization: None of the platforms natively support on-chain dialogue, annotations, or reflective storytelling - learners must export to off-chain forums or social media to internalize and share insights.

Incentive Design: Only Badgr's gamified leaderboards and LEF's experimental "Earn-to-Learn" pilots approach sustained co-creation incentives; the others rely on institutional mandates or one-off token grants.

Dialog & Customization Variations: Badgr's cohort forums enable richer peer-to-peer feedback; LEF's working groups and roadmap channels invite reviewer co-design of protocol extensions; Blockcerts and LearnCoin leave customization in issuer UIs.

Interoperability & Ecosystem Scope: LEF stands out for its cross-platform protocols (Open Skills, W3C wallet) that foster multi-actor credential exchanges, while the others focus on point-to-point issuance.

5 DISCUSSION

Our cross case analysis of LearnCoin, Blockcerts, Badgr, and the Learning Economy Foundation shows that blockchain platforms uniformly excel at codifying and recombining explicit knowledge supporting SECI ´ s Externalization and Combination modes (Nonaka & Takeuchi, 1995; Grant, 1996) and at embedding routine workflows via smart contracts, confirming their role as operant resources under Service ‑ Dominant Logic (Vargo & Lusch, 2004). However, they consistently under support deeper KM cycles: on-chain Socialization and Internalization remain neglected, and smart contracts seldom enable dynamic pathway reconfiguration.

While all four systems offer High transparency through public auditability, true co-creation requires dialogic engagement and mutual customization capabilities, only Badgr and LEF partially address off-chain (Prahalad & Ramaswamy, 2004). Without on-chain channels for annotation, peer review, or iterative feedback, credential ecosystems risk remaining transactional proof repositories rather than transformational learning communities.

These patterns highlight both theoretical and practical imperatives. KM scholars must explore embedding communities of practice and verifiable learning narratives into smart contracts to close the full SECI loop on-chain (Wenger, 1998). Designers should prototype AI-augmented credentialing agents that adapt pathways in real time, extending Service Dominant Logic into fluid ecosystems. Finally, protocol innovations such as multi-phase token economies rewarding issuance, peer annotation, mentoring, and co-design are needed to sustain ongoing collaboration. By mapping both literature

and cases to our integrative model, we fill a critical gap,66 % of prior studies overlook these KM and service-science dimensions and provide a roadmap for next-generation, value-co-creative credentialing systems.

6 CONCLUSION AND FUTURE WORK

Our dual stream review of 50 studies and four platforms (LearnCoin, Blockcerts, Badgr, Learning Economy Foundation) shows that current blockchain credential systems excel at explicit knowledge Externalization and protocol driven resource integration, yet consistently under support, on- chain Socialization, Internalization, and sustained co - creation incentives (Blockcerts, n.d.; Ocheja et al., 2019). By synthesizing SECI (Nonaka & Takeuchi, 1995), Service-Dominant Logic (Vargo & Lusch, 2004), and the co-creation triad (Prahalad & Ramaswamy, 2004), we demonstrate that embedding KM processes such as on-chain communities of practice, narrative annotation layers, and multi-phase token economies, directly into smart contracts is essential to close knowledge - conversion loops and foster dynamic stakeholder engagement.

Building on these insights, future research should:

1) Validate tacit exchanges by empirically examining how on-chain reflective and social interactions support Internalization and Socialization.

2) Augment operant resources through AI-driven credentialing agents and adaptive smart-contract modules that enable real-time resource reconfiguration.

3) Design dialogic governance mechanisms - such as token incentives and schema co-design workflows, which sustain multi-stakeholder collaboration beyond one-off transactions (Markopoulos et al., 2022).

Addressing these issues will deepen theoretical rigor and inform sustainable platform design. Pursuing this agenda will move blockchain - enabled certificates from static proofs of achievement toward living ecosystems of continuous, co - creative learning. Moreover, our model (Figure 1) invites evaluation of socio-technical trade-offs, such as privacy versus transparency, and calls for longitudinal studies to track how on-chain KM processes evolve over time.

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